
A New Subspecies of *Arceuthobium tsugense* (Viscaceae) from British Columbia and Washington

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ABSTRACT. The dwarf mistletoe parasitizing shore pine in British Columbia, Canada, and Washington, U.S.A., is described as a subspecies of hemlock dwarf mistletoe, *Arceuthobium tsugense*, based on morphology and differences in host susceptibility of western hemlock and shore pine to the shore pine dwarf mistletoe, *Arceuthobium tsugense* subsp. *contortae*.

Key words: British Columbia, hemlock dwarf mistletoe, Orcas Island, shore pine, Vancouver Island, western hemlock.

The taxonomic status of the dwarf mistletoe parasitizing shore pine (*Pinus contorta* Douglas ex Loudon var. *contorta*) in British Columbia, Canada, and Washington, U.S.A., has long been debated (Gill, 1935; Hunt & Smith, 1978; Hawksworth, 1987; Hawksworth & Wiens, 1972, 1996; Nickrent & Stell, 1990; Nickrent et al., 1994). This mistletoe was first classified by Gill (1935) as *Arceuthobium campylopodum* Engelm. forma *typicum*. Gill based his classification of *A. campylopodum* on his host form concept, and this dwarf mistletoe was placed in the form that included parasites of *Pinus* spp. (f. *typicum*). In their monograph of *Arceuthobium*, Hawksworth and Wiens (1972) classified the dwarf mistletoe parasitizing shore pine as hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosendahl) G. N. Jones), whose principal host is western hemlock (*Tsuga heterophylla* (Rafinesque) Sargent). However, Hawksworth and Wiens noted that, based on observations reported by Kuijt (1956), shore pines were often severely infected by hemlock dwarf mistletoe in forests where there was little or no infection on western hemlock.

Investigations of the host range of hemlock dwarf mistletoe on Vancouver Island (Smith & Wass, 1976; Wass, 1976) confirmed that western hemlock was much less severely infected by the dwarf mistletoe parasitizing shore pine. Further evidence of the differences in susceptibility of shore pine and

western hemlock to these dwarf mistletoes was demonstrated by a series of artificial inoculation studies. Smith and Wass (1979) demonstrated that the dwarf mistletoe from shore pine produced only a few infections on western hemlock (7% of the inoculations), and only a few shoots were produced on these infections. In addition, these tests found that the dwarf mistletoe from western hemlock caused few infections on shore pine (1%), but the infections produced more shoots. Smith (1974) also demonstrated that dwarf mistletoe from shore pine produced low levels of infection on western hemlock (1%) and no shoots, while dwarf mistletoe from western hemlock produced higher levels of infection (22%) and 100% shoot production on western hemlock. Other inoculation experiments using seeds of the dwarf mistletoe from shore pine also resulted in few infections on western hemlock (3%), but all of the infections produced aerial shoots (Wass, unpublished). Inoculations on shore pine produced many more viable infections (42%) and all of the infections produced shoots. In these experiments, inoculations with seeds from the dwarf mistletoe on western hemlock onto shore pine produced no infections, while 29% of seeds inoculated on western hemlock produced infections and 93% of these produced aerial shoots (Wass, unpublished).

Hawksworth (1987) summarized the taxonomy of hemlock dwarf mistletoe and separated this species into three different races: a western hemlock race, a shore pine race, and a mountain hemlock race. Hawksworth et al. (1992) presented another interpretation for the classification of hemlock dwarf mistletoe. They described the mountain hemlock race proposed by Hawksworth (1987) as a subspecies of hemlock dwarf mistletoe (mountain hemlock dwarf mistletoe—*Arceuthobium tsugense* (Rosendahl) G. N. Jones subsp. *mertensianae* Hawksworth & Nickrent), but maintained the dwarf mistletoe

parasitizing shore pine as a race of hemlock dwarf mistletoe. Nickrent and Stell (1990) reported that their analysis of isozymes could not be used to distinguish the dwarf mistletoe parasitizing shore pine from the mistletoe parasitizing western hemlock and Nickrent et al. (1994) reported that nuclear ribosomal DNA internal transcribed spacer sequences were not useful in distinguishing between the subspecies or races of hemlock dwarf mistletoe. Therefore, in a revision of their monograph on *Arceuthobium*, Hawksworth and Wiens (1996) maintained the race designation for the dwarf mistletoe on shore pine.

In 1997, we began intensive studies of the morphology and host range of hemlock dwarf mistletoe throughout its geographic range. Based on the results of our work, we provide data that support the classification of the dwarf mistletoe parasitizing shore pine in British Columbia and Washington as a subspecies of hemlock dwarf mistletoe, thereby eliminating the use of the race concept in *Arceuthobium*.

***Arceuthobium tsugense* (Rosendahl) G. N. Jones subsp. *contortae* Wass & Mathiasen, subsp. nov.** TYPE: Canada, British Columbia: Vancouver Island, Mount Wells, elevation ca. 335 m, 8 Aug. 2001, *E. F. Wass* 26096 (holotype, DAVFP; isotypes, ASC, MO, US).

Plantae 3–11 (6) cm altae; anthesis mense Julio–Octobri; fructus maturitas Augusto–Novembri. In *Pinus contorta* var. *contorta* parasiticae.

Plants 3–11 cm in height (mean ca. 6 cm); basal diameter of dominant plants 2–5 mm (mean 3 mm); third internode length 5–16 mm (mean 9.95 mm) and 1.75 mm wide; staminate and pistillate plants primarily green-brown, but some yellow-green; staminate flowers 3- or 4-partite; mature fruit length 3.3–5.7 mm (mean 4.6 mm) and 2.1–4.2 mm wide (mean 3.1 mm). Seed length 1.8–3.0 mm (mean 2.5 mm) and width 1.0–1.7 mm (mean 1.4 mm).

Phenology. Anthesis from mid July through early October with peaks in late July to mid August; seed dispersal from mid September to early November with peaks in mid September to mid October.

Habit. Parasitic principally on *Pinus contorta* var. *contorta*, but occasionally parasitic on *Tsuga heterophylla* and rarely on *Pinus monticola* Douglas ex D. Don.

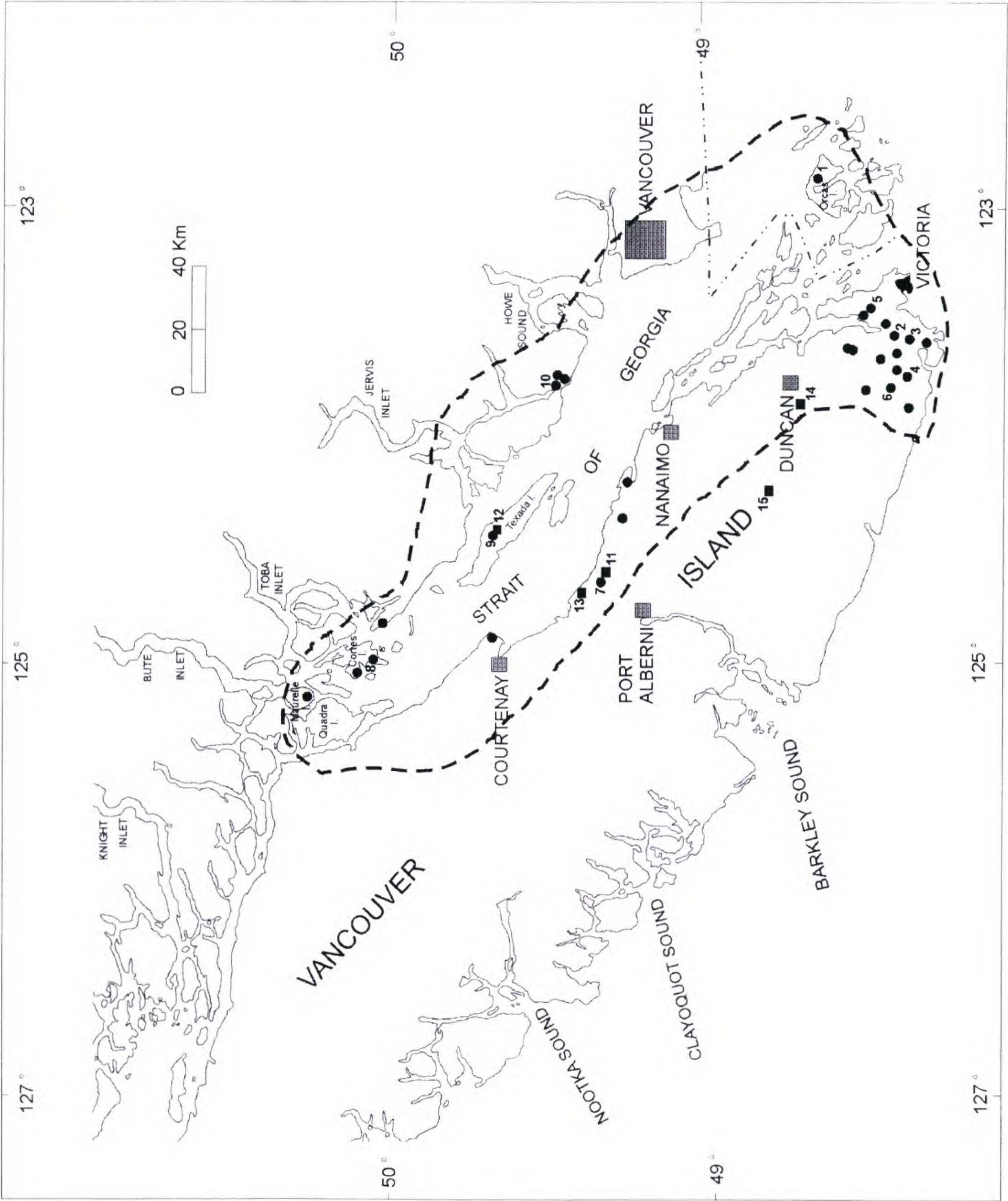
Distribution. Shore pine dwarf mistletoe (SPDM) occurs on Vancouver Island and other islands off the coast of British Columbia as far north as Maurelle Island and on the mainland coast of British Columbia from south of Sechelt to near

Powell River (Fig. 1). There are also reports of SPDM near Port Clements on the Queen Charlotte Islands, on Malcolm Island, and near Terrace, British Columbia (Smith & Wass, 1976; Wass, 1976; Hawksworth, 1987). These represent possible populations of SPDM that are approximately 400–500 km north of the northernmost populations on Vancouver Island or the main coast of British Columbia. Examination of the dwarf mistletoe collection records for the Port Clements and Malcolm Island sites and a visit to the Terrace site indicated that these sites are actually rare crossovers of western hemlock dwarf mistletoe onto shore pine. Therefore, the northern range limit of shore pine dwarf mistletoe is on Maurelle Island (Fig. 1). Elevational range is from near sea level to 800 m.

MORPHOLOGICAL MEASUREMENTS

Ten SPDM populations scattered throughout its principal range in British Columbia and on Orcas Island were sampled (Fig. 1). Five western hemlock dwarf mistletoe (WHDM) populations from within the geographic range of SPDM and 14 other WHDM populations were sampled for comparison (Figs. 1, 2). From each population, 20 infections (10 male and 10 female) were collected and the dominant shoot from each infection was used for morphological measurements. The infections were collected, placed in a cooler to keep them fresh during transport, and stored in a cold room until measured. Plant measurements were made within two days of collection. The dwarf mistletoe plants were measured using a dissecting microscope with a micrometer.

The dwarf mistletoe plant characters measured were those used by Hawksworth and Wiens (1996) for taxonomic classification. The following morphological characters were recorded: (1) height, basal diameter, third internode length and width, and color of the tallest male and female shoot from each infection collected; (2) mature fruit length, width, and color; (3) seed length, width, and color; (4) staminate flower diameter; (5) number, length, and width of staminate perianth lobes; (6) anther distance from the perianth lobe tip; (7) anther diameter; and (8) pre-flowering lateral staminate spike length. Analysis of variance (ANOVA), using a general linear model procedure for unbalanced designs, was used to determine significant differences between shore pine dwarf mistletoe and western hemlock dwarf mistletoe morphological measurements ($F \leq 0.05$). All statistical analyses were performed with SAS computer programs (SAS Institute Inc., 1985).



Male plants of shore pine dwarf mistletoe were significantly shorter (mean 5.6 cm) than those of western hemlock dwarf mistletoe (mean 7.8 cm). Although the range in male plant height of the two mistletoes overlaps somewhat, the tallest plants of SPDM do not reach the maximum heights of WHDM (Table 1). Shoot third internode length was significantly shorter and third internode width was significantly wider for SPDM than for WHDM (Table 1). Staminate flower diameter, perianth length, and perianth width were significantly larger for SPDM than for WHDM. Anther distance from perianth tip was significantly greater for SPDM than for WHDM (Table 1). Another difference between SPDM and WHDM is plant color. Male plants of SPDM are predominantly green-brown whereas male plants of WHDM are predominantly green-yellow. For both mistletoes, the number of perianth lobes on male flowers is three or four, but the predominance of 3-partite or 4-partite flowers varies.

Female plants of shore pine dwarf mistletoe were significantly shorter (mean 6.6 cm) than those of western hemlock dwarf mistletoe (mean 8.0 cm) (Table 2). Again, the range in heights of the dominant female plants overlaps for these mistletoes, but the height of SPDM female plants does not reach the size of those of WHDM (Table 2). Shoot third internode length was significantly shorter for SPDM than for WHDM. The fruit width and seed width of SPDM were significantly wider than for WHDM. The color of female plants of SPDM is predominantly green-brown. Female plants of WHDM are green-brown, green-yellow, or purplish. Fruit and seed color is similar for both mistletoes, as is seed length (Table 2). Table 3 summarizes the principal morphological differences between SPDM and WHDM.

HOST SUSCEPTIBILITY BASED ON NATURAL INFECTION

In order to determine the susceptibility of shore pine and western hemlock to shore pine dwarf mistletoe and western hemlock dwarf mistletoe based on natural infection, 173 temporary plots 6 meters in radius (0.04 ha) were established around large, severely infected residual trees (western hemlock

or shore pine) at 10 locations (Fig. 1). In each plot, trees greater than 1.37 meters in height were sampled and the species and dwarf mistletoe rating (DMR, Hawksworth, 1977) was recorded for each live tree in a plot.

Ninety-nine percent of the shore pine sampled (765 trees) in the plots located in shore pine forests were infected by shore pine dwarf mistletoe (Table 4), and these trees had a mean DMR of 5.0 on a scale of 0–6. This high level of infection clearly demonstrates the high level of susceptibility of shore pine to this mistletoe.

In forests composed of mixtures of shore pine and western hemlock infested with shore pine dwarf mistletoe, 95% of the shore pine was infected, and these trees had a mean DMR of 3.7. Of the 802 western hemlocks sampled in these forests, only 21% were infected by shore pine dwarf mistletoe (Table 4). These western hemlocks only had a mean DMR of 0.3. These infection levels indicate that shore pine is highly susceptible to infection by SPDM while western hemlock is clearly much less susceptible.

In forests of mixed shore pine and western hemlock infested with western hemlock dwarf mistletoe, 96% of the 138 western hemlock sampled were infected (Table 4). These trees were severely infected because their average DMR was 4.3. In contrast, WHDM infection of the shore pine sampled (77 trees) was only 1% with an average DMR of only 0.1. These infection incidences demonstrate the high susceptibility of western hemlock to WHDM (a principal host) and the very low susceptibility of shore pine (a rare host) (Table 4).

SHORE PINE DWARF MISTLETOE

Plants of shore pine dwarf mistletoe and western hemlock dwarf mistletoe have morphological similarities, but they also have some consistent morphological differences (Table 3). Male and female plants of SPDM are consistently smaller than WHDM. In addition, the color of male SPDM plants is frequently green-brown and occasionally yellow-green, while the color of WHDM male plants is consistently yellow-green. Staminate flowers of SPDM are consistently larger than the flowers of

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Figure 1. Dashed line encloses the distribution of *Arceuthobium tsugense* subsp. *contortae*. Black circles indicate known populations and numbered circles indicate populations sampled for morphological measurements and host susceptibility: Washington: 1—Orcas Island; British Columbia: 2—Mount Wells, 3—Mount Helmcken, 4—Bluff Mountain, 5—Mount Work, 6—Trap Mountain, 7—Spider Lake, 8—Cortes Island, 9—Texada Island, 10—Sechelt. Black squares indicate populations of *Arceuthobium tsugense* subsp. *tsugense* sampled for morphological measurements and host susceptibility: British Columbia: 11—Spider Lake, 12—Texada Island, 13—Bowser, 14—Holt Creek, 15—Caycuse Summit.

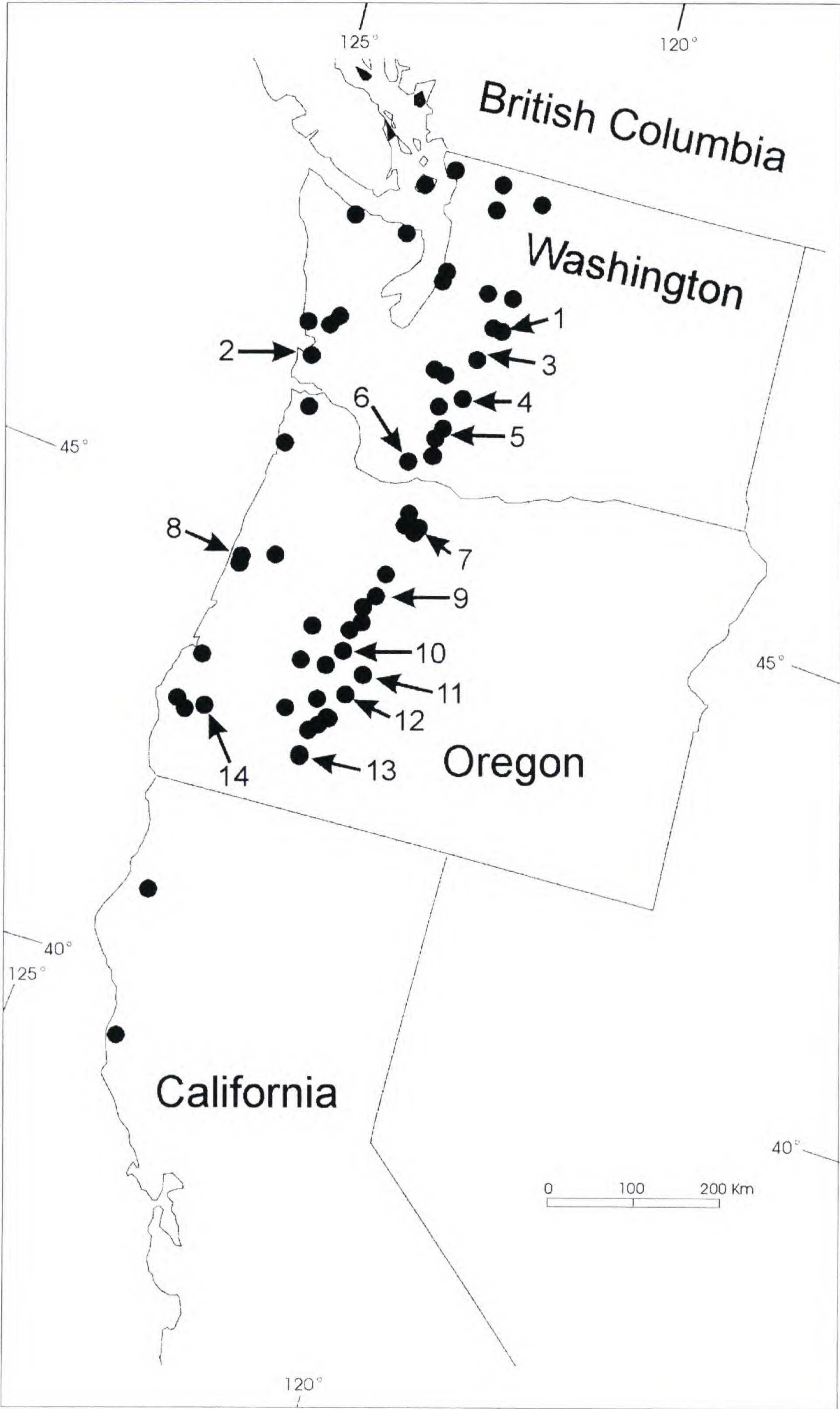


Figure 2. Distribution of *Arceuthobium tsugense* subsp. *tsugense* in Washington, Oregon, and California (Hawksworth & Wiens, 1996). Black circles indicate known populations and numbered circles indicate populations where mor-

Table 1. Morphological characteristics of male plants for shore pine and western hemlock dwarf mistletoes for collections from British Columbia and the United States.

Male plant characters*	Shore pine dwarf mistletoe			Western hemlock dwarf mistletoe			Probability >F
	Mean	Range	N/n**	Mean	Range	N/n	
Tallest shoot length	5.6	3.2–10.8	11/110	7.8	3.4–16.1	20/270	0.0001
Shoot basal diameter	2.8	1.7–4.7	11/110	2.6	1.3–5.0	20/269	0.2104
Shoot third internode length	9.2	5.8–15.7	11/110	11.8	4.5–23.0	20/270	0.0001
Shoot third internode width	1.8	1.1–2.5	11/110	1.6	0.8–3.0	20/270	0.0111
Third internode length/width ratio	5.3	2.9–8.8	11/110	7.5	2.7–15.0	20/270	0.0001
Staminate spike length	12.6	5.0–22.0	11/110	10.8	5.0–27.4	16/260	0.1590
Staminate flower diameter	4.3	2.8–5.9	11/110	3.6	2.2–6.4	16/260	0.0056
Anther diameter	0.7	0.4–1.2	11/110	0.7	0.3–1.3	16/260	0.7650
Staminate perianth length	1.8	1.2–2.8	11/110	1.5	1.0–2.2	16/260	0.0015
Staminate perianth width	1.4	1.0–2.3	11/110	1.2	0.8–2.2	16/260	0.0248
Anther distance from perianth tip	0.9	0.4–1.5	11/110	0.5	0.2–1.2	16/260	0.0002

* Shoot length measured in cm; other characters measured in mm.
** N/n: number of populations sampled over number of individual measurements.

WHDM. Because we sampled several populations of both dwarf mistletoes and completed at least 100 measurements of the morphological characters selected for analysis, we feel the morphological differences we found between SPDM and WHDM are consistent and are taxonomically important discontinuities.

The principal host of shore pine dwarf mistletoe is clearly shore pine, and not western hemlock, which we classify as an occasional host of SPDM using the host susceptibility system of Hawksworth and Wiens (1972, 1996). When exposed to western hemlock dwarf mistletoe in mixed western hemlock/shore pine forests, shore pine is a rare host of this mistletoe. These large differences in susceptibility between these hosts represent distinct and consistent physiological discontinuities between these mistletoes and represent taxonomically important characters distinguishing them. Artificial inoculations also indicate that these large differences in host preference exist between SPDM and WHDM (Smith, 1974; Smith & Wass, 1979; Wass, unpublished).

Hawksworth and Wiens (1972, 1996: 146) defined subspecies in *Arceuthobium* as “geographically restricted populations delimited by a few relatively small but consistent variations.” Although the distributions of the shore pine dwarf mistletoe and western hemlock dwarf mistletoe overlap, they have a few consistent morphological differences between them and clearly demonstrate different levels of parasitism on shore pine and western hemlock. Because of these morphological and physiological differences, the SPDM should be recognized as a subspecies of hemlock dwarf mistletoe based on Hawksworth and Wiens’ concept of subspecies in *Arceuthobium*.

Furthermore, giving shore pine dwarf mistletoe taxonomic status at the subspecific level is consistent with the Hawksworth et al. (1992) classification of mountain hemlock dwarf mistletoe as a subspecies of hemlock dwarf mistletoe. Our field studies in the Calapooya Mountains of south central Oregon indicate that mountain hemlock dwarf mistletoe is not geographically restricted from populations of western hemlock dwarf mistletoe. In addition, only

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phological data was collected. Washington: 1—Snoqualmie Pass, 2—Westport, 3—Huckleberry Creek, 4—Cortright Creek, 5—Clearwater Creek, 6—Wind River Experimental Forest; Oregon: 7—Wapinitia Pass, 8—Desolation Saddle, 9—Huckleberry Creek, 10—Indigo Spring, 11—Wall Creek, 12—Calapooya Ridge, 13—Union Creek, 14—Iron Mountain.

Table 2. Morphological characteristics of female plants for shore pine and western hemlock dwarf mistletoes for collections from British Columbia and the United States.

Female plant characters*	Shore pine dwarf mistletoe			Western hemlock dwarf mistletoe			Probability >F
	Mean	Range	N/n**	Mean	Range	N/n**	
Tallest shoot length	6.6	4.0–9.5	11/110	8.0	3.8–13.7	20/265	0.0031
Shoot basal diameter	3.3	1.8–5.0	11/110	2.7	1.3–5.5	20/265	0.0214
Shoot third internode length	10.7	5.3–16.4	11/110	12.3	6.0–22.0	20/265	0.0050
Shoot third internode width	1.7	1.3–2.5	11/110	1.6	1.0–3.1	20/265	0.2584
Third internode length/width ratio	6.2	3.6–9.4	11/110	7.8	3.3–16.0	20/265	0.0007
Fruit length	4.6	3.3–5.7	11/110	4.4	3.3–5.5	18/210	0.2058
Fruit width	3.1	2.1–4.2	11/110	2.9	2.2–3.5	18/210	0.0363
Seed length	2.5	1.8–3.0	10/100	2.6	1.8–3.5	17/200	0.1193
Seed width	1.4	1.0–1.7	10/100	1.1	0.8–1.4	17/200	0.0001

* Shoot length measured in cm; other characters measured in mm.
** N/n: number of populations sampled over number of individual measurements.

a few morphological and physiological differences distinguish these subspecies (Hawksworth et al., 1992; Hawksworth & Wiens, 1996). Differences in plant size, phenology, and host range are the principal characters used by Hawksworth et al. (1992) to separate those subspecies, and these are the same characters that distinguish shore pine dwarf mistletoe from western hemlock dwarf mistletoe (Table 3). Therefore, the classification of shore pine dwarf mistletoe as a subspecies of hemlock dwarf mistletoe, instead of a race, is more consistent with the interpretation for hemlock dwarf mistletoe pro-

posed by Hawksworth et al. (1992) and with the taxonomic framework established in Hawksworth and Wiens' (1996) monograph of *Arceuthobium*.

Arceuthobium tsugense subsp. contortae. *Paratypes*. All citations based on *Pinus contorta* var. *contorta*. U.S.A. **Washington:** San Juan Co., summit of Mount Constitution, Orcas Island, 1921, *Beattie 5801* (FPF); summit of Mount Constitution, 1965, *Graham & Thompson s.n.* (FPF); Mount Constitution, near summit, 1972, *Hawksworth et al. 1442* (FPF); Moran State Park, Orcas Island, 1987, *Hawksworth 2211* (FPF); Little Summit, Orcas Island, 1997, *Mathiasen 9702* (ASC); summit of Mount Constitution, 1997, *Mathiasen 9703* (ASC); midway between

Table 3. Principal morphological and physiological differences between shore pine dwarf mistletoe (SPDM) and western hemlock dwarf mistletoe (WHDM).

Characters	SPDM	WHDM
Mean plant height:		
male	5.6 cm	7.8 cm
female	6.6 cm	8.0 cm
Mean length of third internode:		
male	9.2 mm	11.8 mm
female	10.7 mm	12.3 mm
Mean flower diameter	4.3 mm	3.6 mm
Mean seed width	1.4 mm	1.1 mm
Seed length to width ratio	1.8	2.4
Plant color:		
male	green-brown	yellow-green
female	green-brown	yellow-green/purple
Host susceptibility:		
shore pine	principal host	occasional host
western hemlock	rare host	principal host
Peak seed dispersal	one week earlier than WHDM	one week later than SPDM

Table 4. Infection of shore pine and western hemlock by shore pine dwarf mistletoe and western hemlock dwarf mistletoe.

Dwarf mistletoe	Forest type	Shore pine		Western hemlock	
		Trees sampled	Percent infected	Trees sampled	Percent infected
shore pine	pure shore pine	765	99	—	—
	shore pine and western	811	95	802	21
	hemlock mix				
western hemlock	western hemlock and shore pine mix	77	1	138	96

Little Summit and Mount Constitution, 1997, *Mathiasen* 9705 (ASC). CANADA. **British Columbia:** Vancouver Island, Metchosin, 1954, *Kuijt* 602 (FPF); Vancouver Island, Horne Lake, 1954, *Kuijt s.n.* (FPF); Horne Lake, 1969, *R. S. Smith s.n.* (FPF); Horne Lake, 1977, *Hawsworth* 1814 (FPF); Horne Lake, 1987, *Nickrent* 2664 (FPF); Horne Lake, 1997, Vancouver Island, Courtenay, 1954, *Foster s.n.* (FPF); Vancouver Island, Goldstream, near summit of Mount Finlayson, 1965, *Ziller s.n.* (FPF); Vancouver Island, summit of Mount Finlayson, 1987, *Nickrent* 2666 (FPF); Vancouver Island, Nanoose Bay, 1954, *Kuijt s.n.* (FPF); Savary Island, 1918, *Davidson s.n.* (FPF); Vancouver Island, Spider Lake, 6 km S of Qualicum, 1987, *Nickrent* 2665 (FPF); Spider Lake, Lakeview Rd., *Wass* 26851 (♂) and 26852 (♀) (DAVFP); mainland British Columbia, Sechelt, 1954, *Kuijt s.n.* (FPF); Sechelt, 1997 and 1998, *Wass* 26861 (♂) and 26862 (♀) (DAVFP); Cortes Island, Mansons Landing, 1997, *Wass* 26853 (♂) and 26854 (♀) (DAVFP); Vancouver Island, summit of Mount Helmcken, Victoria, 1997, *Wass* 26855 (♂) and 26856 (♀) (DAVFP); Vancouver Island, summit of Bluff Mountain, Sooke, 1997, *Wass* 26857 (♂) and 26858 (♀) (DAVFP); Vancouver Island, summit of Mount Work, Sidney, 1997, *Wass* 26859 (♂) and 26860 (♀) (DAVFP); Vancouver Island, summit of Trap Mountain, Sooke, 1998, *Wass* 26865 (♂) and 26866 (♀) (DAVFP); Texada Island, Mt. Pocahontas Rd., 1997 and 1998, *Wass* 26863 (♂) and 26864 (♀) (DAVFP).

Arceuthobium tsugense subsp. *tsugense*. *Paratypes*. All citations based on *Tsuga heterophylla*. U.S.A. **Washington:** Skamania Co., Wind River Experimental Forest, 1998 and 2000, *Mathiasen* 98125 (♀) and 0028 (♂) (ASC); Clearwater Creek, 1998 and 2000, *Mathiasen* 98126 (♀) and 0029 (♂) (ASC); Lewis Co., Cortright Creek, 1998 and 2000, *Mathiasen* 98127 (♀) and 0030 (♂) (ASC); Pierce Co., Huckleberry Creek, 1998 and 2000, *Mathiasen* 98128 (♀) and 0031 (♂) (ASC); Kittitas Co., Snoqualmie Pass, 1998 and 2000, *Mathiasen* 98129 (♀) and 0032 (♂) (ASC); Grays Harbor Co., Westport, 1998, *Mathiasen* 98130 (♀) (ASC); Oregon: Jackson Co., NE of Union Creek, 1998 and 2000, *Mathiasen* 98113 (♀) and 0034 (♂) (ASC); Douglas Co., Calapooya Ridge, 1998, *Mathiasen* 98116 (♀) (ASC); Lane Co., Indigo Springs, 1998 and 2000, *Mathiasen* 98118 (♀) and 0033 (♂) (ASC); Wall Creek, 1998 and 2000, *Mathiasen* 98121 (♀) and 0035 (♂) (ASC); Huckleberry Creek, 1998 and 2000, *Mathiasen* 98122 (♀) and 0036 (♂) (ASC); Wasco Co., Wapinitia Pass, 1998 and 2000, *Mathiasen* 98124 (♀) and 0037 (♂) (ASC); Lincoln Co., Desolation Saddle, 1998, *Mathiasen* 98131 (♀) (ASC); Coos Co., E of Iron Mountain, 1998, *Mathiasen* 98132 (♀) (ASC). CANADA.

British Columbia: Vancouver Island, Spider Lake, Qualicum Beach, 1997, *Wass* 26869 (♂) and 26870 (♀) (DAVFP); Texada Island, Mt. Pocahontas Rd., 1997 and 1998, *Wass* 26871 (♂) and 26872 (♀) (DAVFP); Vancouver Island, Holt Creek, Duncan, 1998, *Wass* 26873 (♂) and 26874 (♀) (DAVFP); Vancouver Island, Caycuse Summit, Honeymoon Bay, 1997 and 1998, *Wass* 26875 (♂) and 26876 (♀) (DAVFP); Vancouver Island, 1.2 km up Crosby Rd., Bowser, 1998, *Wass* 26877 (♂) and 26878 (♀) (DAVFP).

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Literature Cited

Gill, L. S. 1935. *Arceuthobium* in the United States. Connecticut Acad. Arts Sci., Trans. 32: 111–245.

Hawsworth, F. G. 1977. The 6-class dwarf mistletoe rating system. Gen. Techn. Rep. R.M.-48, U.S.D.A. Forest Serv.

———. 1987. Taxonomy of hemlock dwarf mistletoe. In: S. J. Cooley (editor), Proceedings, 34th Annual Western International Forest Disease Work Conference; 1986 September 8–12; Juneau, Alaska. Portland, Oregon. U.S.D.A., Forest Serv., Forest Pest Managem.: 45–46.

——— & D. Wiens. 1972. Biology and classification of dwarf mistletoes (*Arceuthobium*). U.S.D.A., Forest Serv. Agric. Handb. 401.

——— & ———. 1996. Dwarf mistletoes: Biology, pathology, and systematics. U.S.D.A., Forest Serv. Agric. Handb. 709.

———, ——— & D. L. Nickrent. 1992. New western North American taxa of *Arceuthobium* (Viscaceae). Novon 2: 204–211.

Hunt, R. S. & R. B. Smith. 1978. Natural infection of two new hosts by hemlock dwarf mistletoe in British Columbia. Canad. Pl. Dis. Surv. 58(2): 31–32.

Kuijt, J. 1956. A new record of dwarf mistletoe on lodgepole and western white pine. Madroño 13: 170–172.

Nickrent, D. L. & A. L. Stell. 1990. Biochemical systematics of the *Arceuthobium campylopodum* complex (dwarf mistletoes, Viscaceae). II. Electrophoretic evidence for genetic differentiation in two host races of hemlock dwarf mistletoe (*Arceuthobium tsugense*). Biochem. Syst. Ecol. 18: 267–280.

———, K. P. Schuette & E. M. Starr. 1994. A molecular phylogeny of *Arceuthobium* (Viscaceae) based on nucle-

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- ar ribosomal DNA internal transcribed spacer sequences. *Amer. J. Bot.* 81: 1149–1160.
- SAS INSTITUTE INC. 1985. SAS user's guide: Statistics, Version 5 Ed. SAS Institute Inc., Cary, North Carolina.
- Smith, R. B. 1974. Infection and development of dwarf mistletoes on plantation-grown trees in British Columbia. *Canad. Forest Serv., Pacific Forestry Centre, Inform. Rep. BC-X-97.*
- & E. F. Wass. 1976. Field evaluation of ecological differentiation of dwarf mistletoe on shore pine and western hemlock. *Canad. J. Forest. Res.* 6: 225–228.
- & ———. 1979. Infection trials with three dwarf mistletoe species within and beyond their known ranges in British Columbia. *Canad. J. Pl. Pathol.* 1: 47–57.
- Wass, E. F. 1976. Ecology of shore pine stands infested with dwarf mistletoe on southeastern Vancouver Island. *Canad. Forest Serv., Pacific Forestry Centre, Inform. Rep. BC-X-142.*